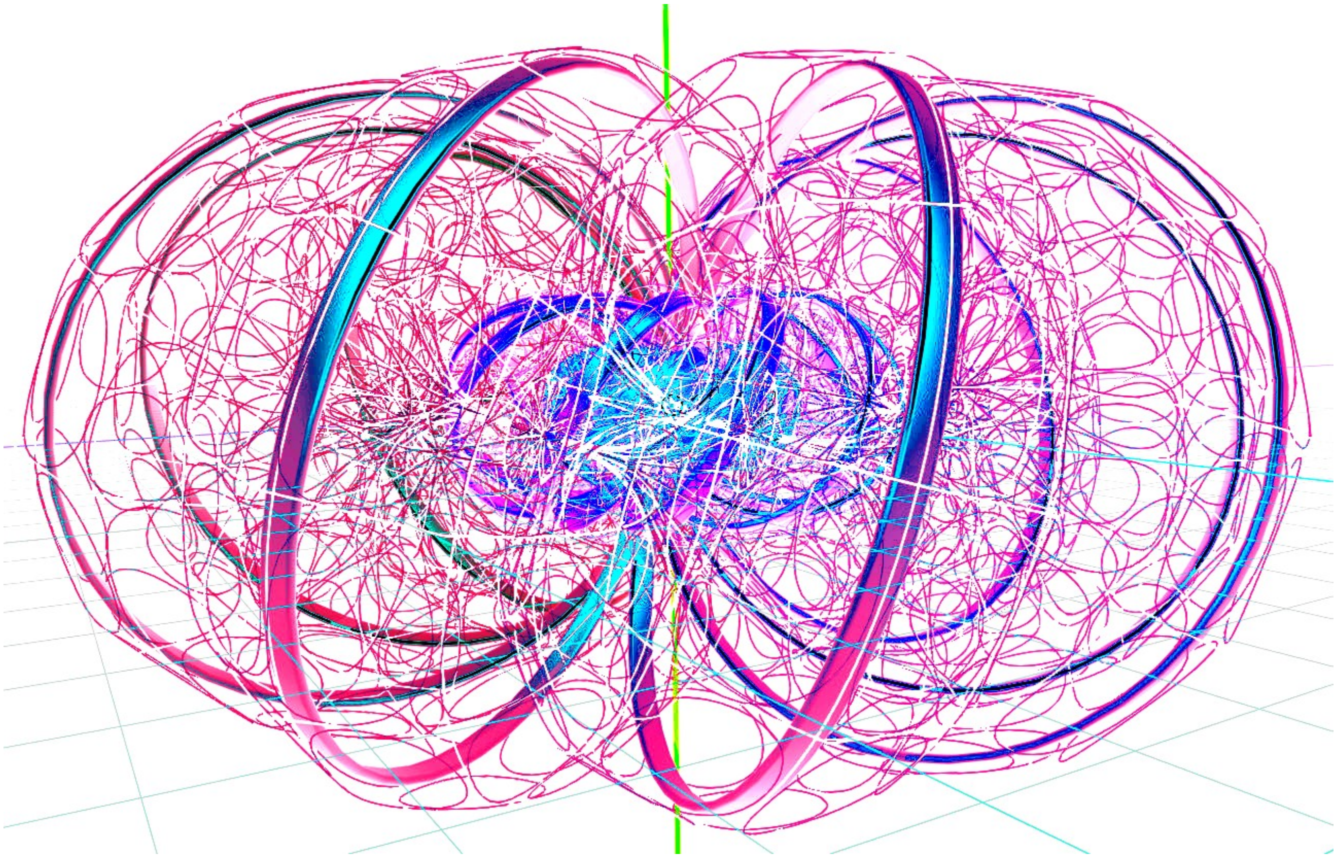
# *The Solidifying Past: Gravity as the Compression of Non-Events*

Brent Hartshorn August 1st, 2025



Above: Hopf Fibration of a 4-D Sphere

**Abstract**

This paper proposes a novel conceptual framework for understanding the quantum vacuum, gravity, and the arrow of time, departing from traditional interpretations. We introduce the hypothesis that the fundamental "bits" of reality are not solely defined by what *did* happen, but critically by the vast, unactualized potential of "what *did not* happen." Drawing upon the statistical concept of Markov blankets, we suggest that the vacuum state is dynamically defined and continuously refined by the compression of these non-events. We explore the implications of this continuous compression, positing that the observed phenomenon of gravity arises from the iterative compaction of these informational bits, leading to a shrinking and solidifying past and a progressively more finite future.

# PART I

## *Solidifying The Past*

### 1. Introduction: The Enigma of the Vacuum and the Quest for Quantum Gravity

The vacuum in quantum field theory is far from empty; it is a vibrant, fluctuating sea of virtual particles and fields, yet its precise definition and its role in quantum gravity remain elusive. Standard models struggle to reconcile gravity with quantum mechanics, often leading to divergences and conceptual impasses. Furthermore, the nature of information at the most fundamental level—what constitutes a "bit" of reality, and how it is processed or compressed—is a profound unanswered question, *particularly in the absence of an explicit observer***.**

This paper introduces a radical departure from conventional approaches by proposing that the fundamental informational content of the universe is predominantly defined by "what *did not* happen." We posit that spacetime itself is not a static, expansive arena, but rather a dynamic process of continuous informational compaction. We leverage the concept of Markov blankets, typically used to delineate systems in statistical inference and cognitive science, to define the boundary between realized events and the immense landscape of unactualized possibilities, which we term the "negative space" of reality.

## 2. The Negative Space of Reality: Bits of What Didn't Happen and their Markov Blankets

### 2.1 Reframing Fundamental Information and the Vacuum as a Markov Blanket

Traditional physics primarily focuses on describing "what is" or "what happened." We propose an inversion: the universe's fundamental informational structure is predominantly constituted by the "bits of what didn't happen." Imagine a vast, incomplete graph representing all possible events. At any given "now" moment, only a tiny fraction of these possibilities are actualized. The overwhelming majority remain unrealized. We suggest that these unrealized possibilities are the primary carriers of information processing, and their continuous refinement and compression drive the dynamics of reality.

We define the **vacuum** as the **internal state** of a universal Markov blanket, $MB_U$. This blanket statistically partitions the entire state space of the universe into:

- **Internal States ($I_U$):** The "vacuum" itself, representing the unactualized potentials and the informational content of "what didn't happen."
- **Sensory States ($S_U$):** Information flowing *into* the vacuum, representing the influence of actualized events or external constraints.
- **Active States ($A_U$):** Information flowing *out of* the vacuum, representing its influence on the actualized universe.
- **External States ($E_U$):** Truly impossible or irrelevant non-events, conditionally independent of $I_U$ given $S_U$ and $A_U$.

The Markov blanket $MB_U=\{S_U,A_U\}$ renders the internal vacuum states $I_U$ conditionally independent of the external states $E_U$. The vacuum, in this context, is not an empty void, but rather the dynamic, information-rich state comprising these unactualized potentials, continuously being defined and refined by the evolution of its Markov blanket.

### 2.2 Space as a Compacting Medium and the Emergence of Gravity from Blanket Compression

Instead of space being a free, expansive dimension for things to move in, we propose that "space" is inherently shrinking and compacting. This compaction acts upon all bits—newly actualized events, old events, and crucially, the bits representing what didn't happen, which reside within the vacuum's Markov blanket. This iterative process of compression, accumulating previous steps, leads to a "compression limit." We hypothesize that this compression limit manifests as the phenomenon we perceive as *gravity*. The more information that is compressed (i.e., the more "what didn't happen" is solidified within $I_U$ by the dynamics of $MB_U$), the stronger the gravitational effect. This suggests gravity is an emergent property of informational compaction, a consequence of the universe continuously solidifying its past by eliminating unrealized potential through the dynamic evolution of its vacuum Markov blanket.

### 2.3 The Incomplete Graph and Solidifying Past via Blanket Dynamics

At each "now" moment, it is impossible to set all the bits of what is happening everywhere. Instead, we begin building an incomplete graph of "what didn't happen." This graph is not static; it is dynamically refined and compressed over time. As this compression proceeds, the bits of what didn't happen become more "solidified," meaning the range of past possibilities shrinks, and the actualized past becomes increasingly consistent and defined. This process of the past solidifying slowly, driven by the compression of unactualized states within the vacuum's Markov blanket, is central to our proposed mechanism for gravity. The evolution of this graph is directly tied to the internal dynamics of $I_U$ and its interaction with $S_U$ and $A_U$.

### 2.4 A New Perspective on Motion and Time

In this framework, motion transcends simple displacement within a static Euclidean arena. Instead, it is deeply intertwined with the universe's fundamental informational dynamics, specifically the ongoing compression of unactualized possibilities, or "non-events". The model observes an apparent smoothness of motion at very large scales, such as galactic orbits, attributed to the long-range coherence of the cosmic wave function and the relatively uniform distribution of energy in the steady state. Similarly, at the smallest scales, the wave-like behavior of particles, as described by quantum mechanics, also exhibits a degree of smoothness. This contrasts sharply with the "sharpness" observed at the human scale, which is posited to arise from "complex interactions, friction, and the need for directed force". This scale-dependent behavior is understood to reflect underlying properties of the steady-state vacuum and the unique manner in which energy and information propagate through it.

Acceleration, a seemingly straightforward mechanical process, is radically reinterpreted within this paradigm. It is not viewed as an isolated event, such as a rocket expelling matter backward to gain speed, but rather as a dynamic interaction within a single, larger system. The act of generating an unbalanced force, which introduces "new information" into the system, creates a "two-directional expansion": the ship moves forward, and matter/energy are propelled backward. Counter-intuitively, this apparent outward propulsion is understood to *point towards a global, inward-falling direction of compacting information*. This interpretation implies a dynamic and responsive cosmos, constantly adjusting its informational equilibrium, where even the acceleration of a single proton infinitesimally contributes to the ongoing cosmic compression.

Time itself is fundamentally redefined in this model. It is not an external, independent clock, but rather: points to the direction of increasing information compression, a relentless movement towards greater informational density, organization, and perhaps, ultimate cosmic self-awareness. This provides a unified, information-theoretic arrow of time, intrinsically linked to the gravitational process and the irreversible compression of Markov blankets.

### 2.5 Rotation and Dimensionality in the Steady-State Context

This paper links the requirement of three dimensions for stable rotation, as observed in knot theory, to the topological properties of the steady-state universe. The ability to form stable knots, which are intrinsically three-dimensional structures, is proposed as a consequence of the "dimensionality of the vacuum energy" and the way it constrains the flow of information and energy. In higher dimensions, the instability of knots suggests that "information and energy can be lost".

Furthermore, the challenge posed by the *relativity of simultaneity* in defining rotation within a relativistic framework is considered less problematic in a steady-state universe where there is a preferred frame of reference defined by the cosmic wave function. This "cosmic wave function" provides a consistent backdrop against which rotation can be defined, offering a departure from purely relative motion. The conceptual overlap between this "cosmic wave function" and the Cosmic Microwave Background (CMB) is significant. The Carmichael 4-sphere Matrvoskha model explicitly identifies the CMB as a "stable, all-encompassing finite shell," acting as a "reference surface." This suggests that within this theoretical framework, the "cosmic wave function" is not merely an abstract mathematical construct but has a tangible physical manifestation in the form of the CMB. This elevates the CMB from a relic radiation to a fundamental quantum boundary or state that dictates the universe's preferred motion and informational equilibrium.

Given the CMB's proposed role as a preferred reference frame and the physical manifestation of the "cosmic wave function" within this model, further high-precision analysis of CMB anisotropies might reveal subtle imprints of the universe's underlying informational compression dynamics. If the CMB truly embodies the "cosmic wave function", then its anisotropies might carry subtle, yet detectable, signatures of the *process* of informational compression, rather than just initial conditions. This could manifest as non-Gaussianities or specific large-scale alignments that go beyond standard inflationary predictions, reflecting the universe's ongoing adjustment to informational equilibrium and the subtle influence of global curvature. This could involve searching for specific non-Gaussianities, large-scale alignments (e.g., the "axis of evil"), or deviations from standard cosmological model predictions for power spectra that are not explained by inflationary models, but rather reflect the "solidification of non-events" or the influence of the evolving geometry of time on the early universe.

Julian Barbour's approach to physics, known as relational dynamics, offers a profound alternative to traditional frameworks by positing that only relative configurations, or "shapes," are physically meaningful. Absolute positions or times are considered unobservable and therefore physically irrelevant. Dynamics, in this view, arise solely from changes in these relative shapes.

**3. The Julian Barbour "Best Matching Method"**

Central to Julian Barbour's relational dynamics is the "best matching method." This technique seeks to identify the optimal possible match between successive configurations of a system, effectively eliminating redundant degrees of freedom associated with absolute space and time. This method is like a normalization at each time step that removes the vacuum or a compression step. Barbour's method specifically aims to bring "the centers of Mass to coincidence and the angular momentum to zero," and can also be extended to bring "the dilational momentum to zero".

If the "vacuum" is understood as the realm of "unactualized potentials" or "bits of what didn't happen," then Barbour's "removing the vacuum" via "best matching" can be interpreted as precisely the act of compressing and solidifying these non-events. This suggests that Barbour's relational dynamics, and specifically the "best matching method," could represent the *fundamental compression algorithm*.

**3.1 Dilational Momentum and Riemann Zeta Zeros**

A particularly intriguing aspect of Barbour's work, is the concept of "dilational momentum" and its unexpected connection to the Riemann zeta function. Barbour states that he coined the term "dilational momentum" in 2003. The connection to the Riemann hypothesis arises from the work of Michael Berry, who discovered a quantum mechanical Hamiltonian whose eigenvalues appear to reproduce many of the zeros of the Riemann zeta function. Berry's work, as Barbour notes, is based on the "dilational momentum of a single particle in a plane". Barbour himself explored the possibility of setting dilational momentum to zero eternally over two decades ago, but abandoned it because it is not conserved by Newtonian gravity, which requires a homogeneous potential of degree -2, whereas the Newtonian gravitational potential is of degree -1.

The explicit link between Barbour's dilational momentum and Riemann zeta zeros, via Michael Berry's work, suggests a profound number-theoretic underpinning for cosmic information compression. If dilational momentum, a component of the universe's "compression" mechanism (as inferred from the "best matching" interpretation), is connected to the zeros of the Riemann zeta function—a deep problem in number theory concerning the distribution of prime numbers, which are fundamental "bits" of integers—then it implies that the fundamental process of informational compression and the "solidification of non-events" might be governed by highly ordered, mathematically structured principles. This suggests that the "bits of what didn't happen" and their dynamic compression are not arbitrary but follow a precise, mathematically defined evolution, potentially revealing a hidden, deep order in the universe's informational fabric. This connection could open new avenues for exploring the universe's fundamental "code" through the lens of number theory and quantum chaos.

Barbour also discusses the existence of solutions with exactly zero energy and angular momentum as a set of measure zero in normal Newtonian terms, and then raises the question of whether an "even smaller set of measure zero within the set of measure zero" might exist. This concept aligns with the idea of a highly specific, unique "best-matched" or maximally compressed informational state that the universe strives towards.

**4. The Philip Carmichael Matrvoskha Universe**

A conceptually aligned framework, referred to as “The Matryoskha 4-sphere model” by Philip Carmichael [1], offers a tangible pathway for empirical validation. This model shares significant conceptual overlap with this "Solidifying Past" model, particularly concerning the nature of rotation, the existence of preferred reference frames, and a redefinition of the cosmic constant 'c'. A key aspect of this alignment is the implicit integration of the 4-sphere geometry within this "Solidifying Past" theory itself, as part of it’s steady state or part of the phase transition triggered by life. Carmichael’s paper indicates that the vector nature of 'c' implies movement "radially inward through the 4-sphere", suggesting that the 4-sphere is not merely a similar conceptual model, but a specific geometric framework already embedded within the core theoretical structure. Crucially, Philip Carmichael’s 4-sphere model explicitly proposes a ground-based interferometry experiment, offering a direct and measurable pathway for empirical validation.

**4.1 The Carmichael 4-Sphere Model's Definition of Rotation**

The Philip Carmichael 4-sphere model offers a fresh perspective on the long-standing debate concerning rotational motion, engaging with the insights and challenges posed by physicists such as Newton, Bohr, and Einstein. Newton attributed rotational motion to absolute space, a concept largely abandoned after experiments like Michelson-Morley. Niels Bohr, influenced by Mach’s principle, believed rotation must be relative to the mass of the entire universe, though the mechanism for such sensing remained unclear. Einstein's relativity, in contrast, defines motion through the invariant speed of light, regulating causality and information flow, without an absolute reference for rotation.

In the Carmichael 4-sphere framework, the Cosmic Microwave Background (CMB) is proposed as a "stable, all-encompassing finite shell," acting as a "reference surface against which angular momentum might be meaningfully defined." This aligns with the spirit of Mach's principle, where objects rotate with respect to the 4-sphere which, encompassing the entirety of mass and energy, provides a universal reference. The model further suggests that the curvature of the time axis, a persistent (though diminishing) feature of the universe, may continue to exert subtle influences on rotational systems even today. This implies that rotation may have behaved differently in the early universe, and that an object like an interstellar mop "might 'know' it is rotating not by sensing space and mass, but by responding to the evolving geometry of time itself."

**Table 1: Comparison of Rotational Reference Frames and Their Implications**

| Model/Theory | Definition of Rotation | Preferred Frame | Mechanism of Inertia | Testable Implications for Rotation |
|---|---|---|---|---|
| Newtonian Absolute Space | Relative to absolute space | Yes (absolute space) | Intrinsic property of matter | None (absolute space untestable) |
| Einsteinian Relativity | Relative to other objects/invariant speed of light (no absolute rotation) | No (local inertial frames only) | Spacetime curvature | Sagnac effect (relative rotation) |
| Mach's Principle (Bohr) | Relative to the mass of the universe | Yes (mass of universe) | Interaction with distant masses | Unclear direct test of Mach's principle |
| 4-Sphere / Solidifying Past Model | Relative to the CMB/4-sphere/evolving geometry of time | Yes (CMB/TIF, defined by cosmic wave function/inward compression) | Interaction with global informational compression/geometry of time | Non-reciprocal phase shift relative to CMB |

### 4.2 Reinterpretation and Evolution of the Equivalence Principle

The Carmichael 4-sphere model also has profound implications for the Equivalence Principle. It reinterprets the principle by distinguishing "true inertial observers" (TIOs) at rest relative to the CMB from other inertial frames, raising questions about the traditional understanding of the principle. The model argues that the principle has always rested on an "ambiguous notion of what constitutes a 'local' region". While it "likely holds at truly microscopic scales," the fact that anisotropies can be detected over human-scale distances suggests it "may begin to break down at larger scales".

In this radical view by Carmichael, 'c' is reframed as the "speed of time," leading to a new form of the equivalence principle: "no observer can distinguish between light reaching them at speed c and time pushing them into light at speed c" – a "time-light symmetry" essential for the model's compatibility with general relativity. This is proposed as an "extension of the principle" that "incorporates the geometric directionality of time and recognizes the subtle influence of global curvature on local measurements".

Carmichael's suggestion that the equivalence principle "likely holds at truly microscopic scales" but "may begin to break down at larger scales" finds a compelling explanation within this framework. Hartshorn posits that other fundamental forces (strong nuclear, weak nuclear, and electromagnetism) "operate at scales where their associated information states are already fully compressed," (when probing the small scale we see the compressed physics) while gravity "represents the ongoing, larger-scale, and slower process of achieving that compression across vast swathes of spacetime and matter". This establishes a direct causal link: the equivalence principle, like other fundamental physical laws, is not universally immutable but rather *emergent* from the underlying state of informational compression. At microscopic scales, where information is highly compressed and stable, the principle holds robustly. At larger scales, where gravity represents *ongoing* compression and the global informational geometry (the "inward-falling direction of compacting information") is still evolving, subtle influences become detectable. This leads to an apparent "breakdown" or, more accurately, an evolution of the principle, implying that the very nature of physical laws is tied to the universe's informational state and the scale of observation. This suggests that the equivalence principle is not a universally immutable law, but rather an emergent property whose validity is contingent on the scale and the underlying state of informational compression.

### 4.3 Relational Dynamics in an Information-Compressed Spacetime

Julian Barbour's relational dynamics, which inherently eliminate absolute space and time by focusing solely on relative configurations, are perhaps not merely a mathematical abstraction but emerge naturally from a universe where spacetime itself is a dynamic process of informational compaction. The "best matching" ensures that only the "solidified" or "compressed" information (the actualized events) defines the shape of reality at any given instant.

Furthermore, the "evolving geometry of time" in Carmichael's model finds a profound explanation in this model of definition of time as pointing to the *direction of increasing information compression*. This implies that relational dynamics is unfolding along this informational time axis. The universe's progression is thus understood as a continuous process of informational refinement and solidification, with each "now" moment representing a new, more compressed informational state.

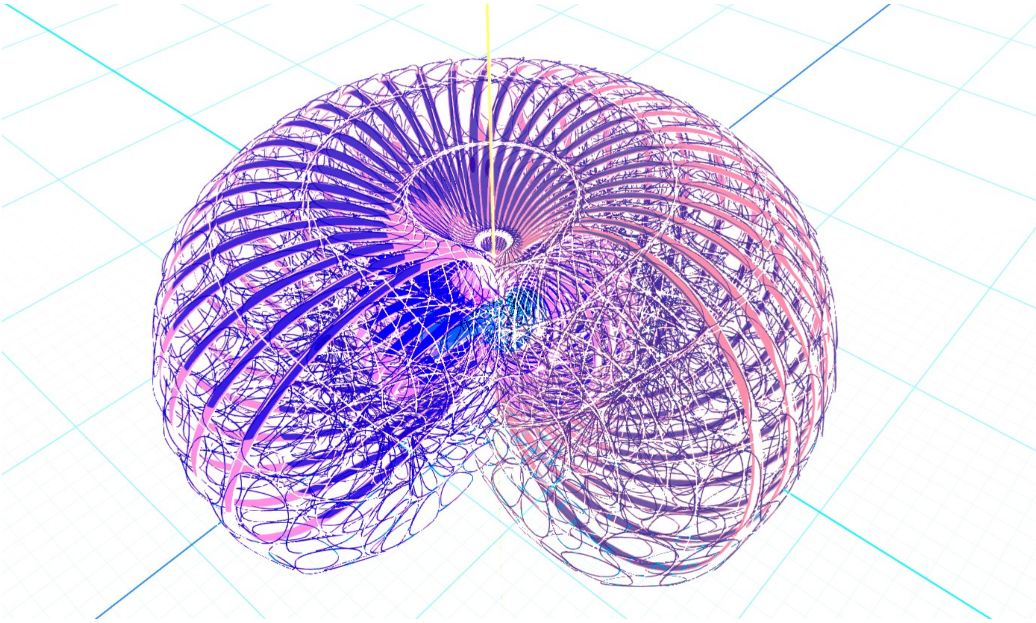
**5. How Motion Relative to Carmichael TIF Alters Light Propagation**

The Carmichael model's vector 'c' implies that "aligning with stability in the universe... requires moving in a specific direction – radially inward through the 4-sphere". A rotating observer, by periodically drifting "in and out of alignment with this stable direction," as its angular momentum carries it through orientations offset from the TIF, would experience altered light propagation. This deviation from the True Inertial Frame (TIF) alignment, specifically due to Earth's tangential velocity from planetary rotation, "should produce a measurable asymmetry in light propagation: a residual redshift or phase shift in an interferometer aligned in different directions". This effect is predicted to be "non-reciprocal" and would "modulate with Earth's sidereal rotation as the interferometer's orientation relative to the CMB changes". This alteration in light propagation is attributed to the influence of a global geometric structure.

Therefore, the "evolving geometry of time" in the 4-sphere model can be understood as the *evolving pattern or rate of informational compression*. A rotating object, such as the mop or Earth, experiences a local perturbation or asymmetry in this global, *inward-falling compression flow* due to its angular velocity relative to the TIF, which is defined by the CMB. This perturbation manifests as the observed inertial effects of rotation, such as the flaring bristles of the mop or the predicted phase shift in an interferometer. This provides a coherent, information-theoretic explanation for Mach's principle, where inertia arises from interaction with the global informational structure of the universe, rather than just its mass distribution. The experimental detection of a non-reciprocal phase shift correlated with Earth's sidereal rotation would provide empirical evidence for this information-centric reinterpretation of rotational inertia, linking local rotational dynamics directly to the global process of informational compression and the fundamental geometry of time.

While Barbour previously abandoned the idea of eternally setting dilational momentum to zero due to its non-conservation in Newtonian gravity, in an information-centric universe where gravity is emergent from compression, the concept might be re-validated. If the CMB-defined TIF represents a state of "zero dilational momentum" (or minimal informational "stretch" or "dilation"), then deviations from this TIF would manifest as non-zero dilational effects. These effects could potentially be detectable by the high-precision interferometer, providing a novel way to observe the consequences of dilational momentum in a universe governed by informational dynamics.

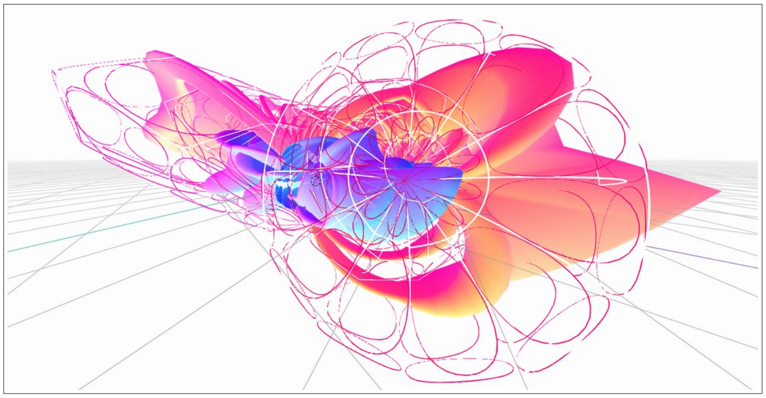
# PART II



**6. Mathematical Framework: Topological Invariants and Information Encoding within Markov Blankets**

To formalize the compression of "what didn't happen" and its connection to gravity and free will, we introduce concepts from topological quantum field theory, explicitly linking them to Markov blankets.

**6.1 Toroidal Ringularity and Information Encoding in the Blanket**



We consider a scenario where complex structures, such as nuclear pasta in a neutron star core, undergo topological changes during collapse. These changes can be described using Khovanov homology.

Nuclear pasta's complex structure can be represented as a network of interconnected "strands." As this network collapses, it undergoes topological changes. Khovanov homology, specifically the Khovanov skein lasagna module S(X;L), can describe these smooth and sharp (non-gauge) changes. We represent the initial nuclear pasta structure as a link $L_0$. As collapse proceeds, $L_0$ transforms into a series of links $L_1, L_2, ..., L_n$, eventually forming a toroidal ringularity.

The Khovanov homology groups $Kh(L_i)$ provide information about the topological invariants of each link $L_i$. The change in these groups, $\Delta Kh(L_i) = Kh(L_{i+1}) - Kh(L_i)$, reflects the topological transitions during the collapse. We propose that these topological changes directly correspond to the re-structuring and compression of the Markov blanket of the collapsing nuclear pasta system, $MB_{NP}$. The "bits of what didn't happen" within the nuclear pasta system's local vacuum are being rapidly solidified.

The final ringularity, represented by $L_n$, corresponds to a torus. The invariants encoded in $Kh(L_n)$ store information about free-will choices at $t \approx T_{transition}$. This information is effectively "written" onto the solidified structure of the local Markov blanket.

**Nuclear Pasta as Link:** $L_0$ **Intermediate Links:** $L_1, L_2, ..., L_{n-1}$ **Ringularity as Torus Link:** $L_n$ **Khovanov Homology Groups:** $Kh(L_i)$

**Topological Transitions:** $\Delta kh(L_i) \leftrightarrow$ *Changes in* $MB_{NP}$

The collapsing shell of nuclear pasta forms a microtubule-like ring singularity, encoding information about free-will choices. We represent each unique axiom of choice, $A_i$, as a ring, forming a chain towards Gödel completeness. The Gödel incompleteness border becomes a hole within the torus. This "hole" represents an *uncompressed undecidable region* within the informational structure of $MB_{NP}$.

**Ring singularity:** Torus(r,R) **Gödel incompleteness border:** Hole(Torus) **Skein Lasagna topological invariants:** S(X;L)

The final ringularity's radius, $r_{final}$, is influenced by free-will actions: $r_{final} = h(M, F_{shell})$

where M is the black hole's mass, and $F_{shell}$ is the free-will action within the collapsing shell. This implies a direct link between the macroscopic structure of spacetime singularities and the microscopic, information-theoretic "choices" made by the universe, which are mediated by the active states of the local Markov blanket $MB_{NP}$.

**3.2 Microtubule Nuclear Pasta Shell Systems in a Steady-State Universe: Interconnected Blankets**

We propose the existence of entangled particle pairs ($E$) within both microtubules ($M$) and nuclear pasta shell systems ($N$). One set of entangled particles evolves into microtubules within life forms, facilitating free-will actions ($F_{life}$), which are mediated by the Markov blanket of the life form, $MB_{Life}$. The other set forms the innermost nuclear pasta shell ($F_{shell}$) of a neutron star core, falling into a ring singularity from black hole collapse, and is influenced by $F_{life}$. The free-will actions within the shell ($F_{shell}$), mediated by $MB_{NP}$, are correlated with $F_{life}$ due to the entanglement pre-existing in a proposed steady-state universe model. This suggests a non-local interaction between distinct Markov blankets.

- **Free-Will Action (Life):** $F_{life} \leftrightarrow$ Active States of $MB_{Life}$
- **Free-Will Action (Shell):** $F_{shell} \leftrightarrow$ Active States of $MB_{NP}$

The correlation function $C(F_{life}, E, N)$ describes how $F_{shell}$ is influenced by $F_{life}$, the initial entanglement, and the state of the nuclear pasta shell. A more detailed form of this function could be:

$$F_{shell}(t) = \alpha F_{life}(t-\tau) + \beta\langle \hat{E}(t=0)\rangle + \gamma\kappa(N(t)) + \delta(\Phi(t) - \Phi_{steady})\Theta(t - T_{transition}) + \eta I(Kh(L_n(t)))$$

Where:

- $F_{shell}(t)$: The free-will action within the collapsing nuclear pasta shell at time t, representing the influence of its Markov blanket's *active states*.
- $\alpha F_{life}(t-\tau)$: The cumulative free-will actions of life forms at a time τ in the past, influencing $MB_{NP}$ via $MB_{Life}$. α is a coupling constant.
- $\beta\langle \hat{E}(t=0)\rangle$: The expectation value of the initial entanglement operator E^ between the particles that will eventually form microtubules in life and the nuclear pasta shell, established during the steady-state period. This initial entanglement can be seen as a pre-established correlation between the internal states of $MB_{Life}$ and $MB_{NP}$. β is a coupling constant.
- $\gamma\kappa(N(t))$: A function κ describing the influence of the nuclear pasta shell's structural properties at time t on $F_{shell}$ (e.g., density, temperature, strand configuration). These properties reflect the current state of $MB_{NP}$'s internal and *sensory states*. γ is a coupling constant.

- $\delta(\Phi(t)-\Phi_{steady})\Theta(t-T_{transition})$: A term representing the influence of a phase transition from the steady state. $\Phi(t)$ is a physical quantity (e.g., vacuum energy density), $\Phi_{steady}$ is its steady-state value, and $\Theta(t-T_{transition})$ is the Heaviside step function, indicating the phase transition effect turns on at $T_{transition}$. This transition affects the overall $MB_U$ and its constituent sub-blankets. δ is a coupling constant.
- $\eta I(Kh(L_n(t)))$: I represents a specific numerical invariant derived from the Khovanov homology groups $Kh(L_n(t))$ of the link $L_n(t)$ at time t. This term aims to capture the influence of the evolving topological information encoded within the internal states of $MB_{NP}$ on its active states ($F_{shell}$). η is a coupling constant.

**4. Markov Blankets and the Dynamic Vacuum**

**4.1 Delineating Realized and Unrealized States with Markov Blankets**

As established, the *vacuum* is the internal state of a universal Markov blanket, $MB_U$. This blanket provides the conceptual and mathematical tools to define the boundary between the "happened" (actualized events, influenced by $A_U$) and the "didn't happen" (the negative space of unrealized potential, constituting $I_U$). The "external states" $E_U$ are truly impossible or irrelevant non-events, while the "sensory" ($S_U$) and "active" ($A_U$) states of $MB_U$ mediate the continuous interaction and compression between the internal vacuum and the external non-events. This implies that the vacuum is not a static background but an active participant in the information dynamics of the universe, constantly processing and compressing the "bits of what didn't happen" within its internal states.

**4.2 Unruh Radiation, High-Temperature Vacuum, and Dark Matter as Blanket Phenomena**

According to Fell's theorem and thermofield double (TFD) states, the vacuum is not uniformly cold; some regions are high-temperature, highly entangled states. We propose that these high-temperature, entangled regions of the vacuum are manifestations of particularly active or dynamic regions within the universal Markov blanket $MB_U$, specifically within its *sensory* and *active* states. The effective temperature within the shell, $T_{eff}(r_p(t),F_{shell})$, and the Unruh particle production rate, $\Gamma_{unruh}(r_p(t),F_{shell})$, are influenced by $F_{shell}$ (the active states of $MB_{NP}$). The energy density of the Unruh radiation, $\rho_U(r_p(t),F_{shell})$, is a function of $\Gamma_{unruh}$.

This dynamic, high-temperature vacuum (the source of "living" Unruh particles) could have a wide-ranging, gravity-like effect, which we propose constitutes a portion of the effects attributed to dark matter. This "dark matter" is effectively the persistent, compressed information within these vacuum Markov blankets, arising from the solidification of non-events.

- **Dark Matter Mass:** $DarkMatterMass=f(\sum UnruhParticles(F_{choice}))$

In the steady-state period, Unruh radiation may have contributed to a form of "latent" dark matter: $\rho_{U,latent}=g(T_{steady})$

where $T_{steady}$ is the temperature of the steady-state vacuum, reflecting a baseline activity level of $MB_U$.

During the phase transition, Unruh radiation becomes more dynamically influential: $\rho_{U,dynamic}=f(t,F_{shell})$

contributing to the expansion. This suggests that the vacuum, as defined by its Markov blanket, can dynamically generate mass-energy that mimics dark matter, driven by the compression of non-events and the influence of free will, which acts as a perturbation on the blanket's dynamics.

**4.3 Compression Limits, Gravity, and Cosmological Evolution within the Universal Markov Blanket**

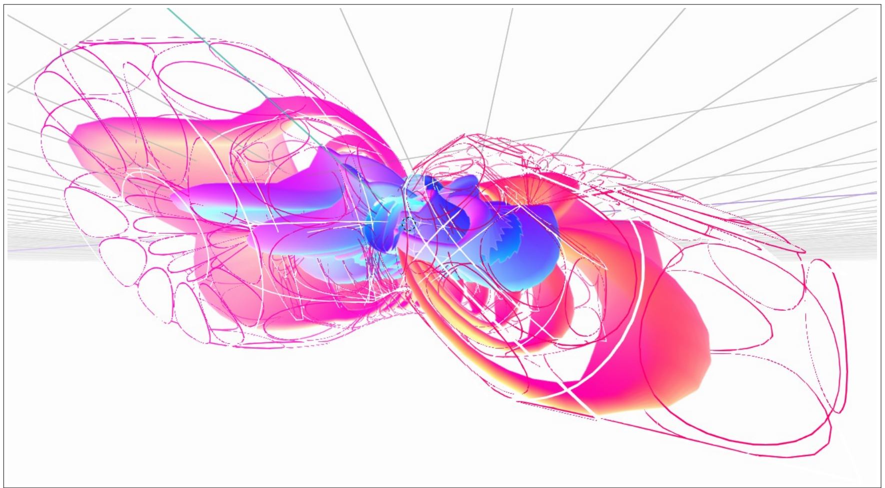
The continuous compression of "what didn't happen" implies a growing density of solidified non-events within the internal states $I_U$ of the universal Markov blanket. As this compression reaches a critical limit, it could explain the emergence of gravity. Furthermore, this framework offers a novel perspective on cosmological evolution:

- Big Bang as a Compression Limit: A universe that was once in a very different perhaps more diffuse steady state, could, through this continuous compression of non-events within $I_U$, eventually reach a point where the past appears to converge to a singularity—the Big Bang. This would be a consequence of the extreme compaction of informational bits defining the early universe's "negative space" within $MB_U$.
- Dark Energy as Residual Expansion: The ongoing expansion of the universe, attributed to Dark Energy, could be interpreted as a residual effect of this compression process. As the future becomes more finite (requiring fewer bits to describe), the compression process might accelerate, leading to an apparent outward "push" or expansion of the remaining "space." This acceleration is driven by the increasing efficiency of information compression within the vacuum's Markov blanket, $MB_U$.

## 5. Quantum Probabilities, Time, and Free Will through Blanket Dynamics

**5.1 Priority Compression of Quantum States and Blanket Solidification**

Within this framework, quantum probabilities are not merely abstract likelihoods but represent the inherent "unsolidified" nature of future events within the internal states $I_U$ of the universal Markov blanket. We propose that the compression process prioritizes the least likely quantum states first. At each "now" moment, the quantum states with the lowest probabilities



are captured and compressed, effectively removing them from the realm of future possibilities. Over many iterations, this process gradually gathers and solidifies the higher probability states. This implies a dynamic, information-compression driven collapse of the wave function, which is fundamentally a process of compression within $MB_U$.

**5.2 Solidifying Past and Shrinking Future via Blanket Evolution**

This preferential compression leads to a dynamically evolving landscape:

- **Growing Consistent Past:** As low-probability futures are compressed away from $I_U$, the past becomes more and more consistent and defined, requiring fewer bits to describe its actualized state. This is a direct consequence of the Markov blanket's internal states becoming more "fixed."
- **Shrinking Future Outcomes:** Conversely, the range of possible future outcomes continuously shrinks. This reduction in future possibilities means that less and less information (fewer bits) is required to store the future, allowing the compression process to become faster. This reflects the progressive reduction of potential states within $I_U$.

**5.3 Gravity, Time Dilation, and Free Will as Blanket Phenomena**

We hypothesize that the perceived effect of gravity is largely due to **time dilation**, rather than solely spatial dilation. In regions of stronger gravitational fields (i.e., higher compression of non-events within $I_U$), time "slows down" because the rate at which future possibilities are compressed and solidified by the local Markov blanket is altered.

The concept of "free will" can also be reinterpreted. The measurement of higher probability states might be delayed, allowing for a "final choice at the end." This suggests that our perception of choice arises from the inherent delay in the compression and solidification of certain quantum outcomes within $I_U$. This "final choice" could be encoded in the topological invariants discussed in Section 3.1, reflecting a specific "selection" made by the active states of a local Markov blanket (e.g., $MB_{Life}$) that then influences the final state of the universal blanket $MB_U$.

**6. Energy Balance and Phase Transition: Blanket-Driven Dynamics**

The collapse of structures like nuclear pasta halts when the Unruh radiation energy equals the shell's energy: $\int \rho_U(r_p(t),F_{shell})dV \approx E_{collapse}$

Here, $\rho_U$ is the energy density of Unruh radiation, which we associate with the dynamic activity of the vacuum's Markov blanket. This balance signifies a temporary equilibrium in the compression process within $MB_{NP}$.

The phase transition from a steady-state universe to an expanding one occurs when the Unruh radiation energy overcomes a critical threshold:

$\int \rho_{U,dynamic}(r_p(t),F_{shell})dV > E_{critical}$ at $t \approx T_{transition}$

This phase transition, $PhaseTransition(r_{phase},F_{shell})$, is influenced by the entangled free-will actions. This transition alters the Gödelian incomplete border group, $U(r_{phase})$, changing the set of undecidable statements and available axioms of choice, A. This implies a fundamental shift in the informational structure of the universal Markov blanket, $MB_U$, and its sub-blankets.

**Gödelian Border Group Change:** $U(r_{phase}) \rightarrow U'(r_{phase})$ **Axiom of Choice Change:** $A(r_{phase}) \rightarrow A'(r_{phase})$ **Free-Will Change:** $F_{shell} \rightarrow F_{shell'}$, $F_{life} \rightarrow F_{life'}$

This suggests a deep connection between the physical dynamics of the universe, the information encoded in its topological structures, and the very foundations of logical completeness and free will, all mediated by the evolving properties of Markov blankets.

**7. Free-Will Embodiment and Gradual Cosmic Expansion: Information Loss from Blankets**

The apparent age of the universe might be misleading; it could be much older, with the current expansion driven by the universe nearing its final perfect glass-like state, a stiff fluid where the speed of sound is equal to the speed of light (in a vacuum). When free-will choices are made, Unruh particles become the embodiment of information, interacting with the dynamic vacuum: $UnruhParticles(F_{choice}) \rightarrow Embodiment$. This "embodiment" represents the actualization of a potential state, which corresponds to a local compression or solidification within the vacuum's Markov blanket. The information loss, $\Delta S(r_p(t),F_{shell})$, is correlated with the information loss from free-will actions in life forms. This information loss drives recent cosmic expansion and increasing order $da/dt = k \cdot d(\sum \Delta S_i)/dt$. This information loss is a measure of the reduction of uncertainty or potential within the relevant Markov blankets.

**8. Information Loss and Cosmic Expansion: Quantifying Blanket Compression**

Information loss ($\Delta S$) from free-will actions drives cosmic expansion ($da/dt$). This loss is explicitly linked to changes in Khovanov homology, providing a quantifiable measure of the "solidification" of non-events within the Markov blankets.

**Cosmic Expansion:** $da/dt = k \cdot dS/dt$ **Information Loss:** $\Delta S(r_p(t),F_{shell}) = \zeta \Delta Kh(L_i)$ Here, $\Delta S_i$ represents the information loss associated with the i-th free-will event or compression step, which corresponds to a change in the entropy of the relevant Markov blanket (e.g., $MB_{Life}$ or $MB_{NP}$). $\zeta$ is a coupling constant relating topological changes to information loss.

**Discrete Information Loss:** $\Delta a = \sum k \cdot \Delta S_i$ This equation suggests that the expansion of the universe is a cumulative effect of these discrete information compression events, each reducing the "negative space" of possibilities.

**9. Gödel Incompleteness and Free-Will as Unique Axiom within the Blanket**

Spacetime is conceptualized as a formal system with Gödelian incompleteness. Free will is proposed as a unique axiom of choice (A(x,t)) within undecidable regions (U(x,t)), causing information loss (ΔS(x,t)). These undecidable regions are precisely where the Markov blanket of the universe, $MB_U$, or its local sub-blankets, are "open" or "unresolved," representing uncompressed potential.

**Undecidable Region:** U(x,t) ↔ Uncompressed states within $MB_U$ or local blankets **Axiom of Choice:** A(x,t) ∈ U(x,t) ↔ A specific selection made by the active states of a local Markov blanket **Information Loss:** ΔS(x,t)=f(U(x,t)−A(x,t))

This suggests that free will, by selecting an axiom within an undecidable region of the Markov blanket's internal states, effectively "compresses" or "solidifies" a part of the negative space, leading to information loss from the perspective of the overall system's potential, and contributing to the universe's evolution. This information loss is a reduction in the entropy of the blanket, reflecting a reduction in the number of possible future states.

**10. Microtubule-Like Standing Wave, Consciousness, and Cosmic Evolution: Blanket-Mediated Interaction**

The ring singularity's standing wave mirrors consciousness, suggesting a deep connection between the structure of black holes and the nature of conscious experience. This standing wave of Unruh radiation could be massless yet more dense than nuclear pasta, representing a highly energetic information processing system. This standing wave can be seen as a highly organized, coherent state within the vacuum's Markov blanket, where information is actively processed and compressed. The free will of life forms acts as a constraint on information flow within the quantum state space, implying that the information that creates free will cannot be traced back. This "untraceability" is due to the inherent compression and solidification of non-events within the Markov blanket, making the "choice" irreversible from an informational perspective. The concept of a "cosmic string" representing the chain and evolution of life is a metaphor for the interconnectedness and temporal continuity of biological systems, suggesting a persistent influence on the universal Markov blanket.

**10.1 Cosmic Evolution and Phase Transition: Blanket-Driven Scale Factor**

Instead of a Big Bang, we propose a long, near-infinite steady-state period: $a(t) \approx a_0$ for $t \lll T_{transition}$ where a(t) is the scale factor, $a_0$ is a constant, and $T_{transition}$ is the time of the phase transition. During this period, the universal Markov blanket $MB_U$ is in a relatively stable, uncompressed state.

The emergence of life and free will triggers a rapid phase transition: $da/dt=f(t,F_{life})$ for $t \approx T_{transition}$ where $F_{life}$ represents the cumulative free-will actions of life forms, which act as a catalyst for the compression of the universal Markov blanket. The current expansion phase is described by: $da/dt=k \cdot d(\sum \Delta S_i)/dt$ for $t>T_{transition}$ where k is a constant, and $\sum \Delta S_i$ is the sum of information loss from free-will actions (i.e., the total compression of the "negative space" within $MB_U$). This provides a unified view of cosmic history, where life and consciousness are not mere byproducts but active drivers of the universe's evolution through their impact on informational compression and the vacuum's Markov blanket.

**11. Exploring the Link Between Quantum Probabilities, Entanglement, and the Proposed Compression Scheme**

Further investigation is needed into how quantum probabilities, entanglement, and the concept of "choice" inherent in free will fit into this compression scheme. The model's reinterpretation of wave function collapse as a "local compression of a Markov blanket" offers a deterministic, yet free-will-compatible, mechanism for quantum measurement.

This suggests that quantum randomness is not irreducible, but rather a reflection of the *uncompressed* state of possibilities within the blanket. Further theoretical work could explore how the "free-will actions" ($F_{life}$, $F_{shell}$) influence the dynamics of these local blanket compressions, potentially leading to a new understanding of the measurement problem and the role of consciousness in the universe's evolution. This could involve modeling the "collapse" of a wave function as a local compression of a Markov blanket, where the least likely quantum states are prioritized for compression. This line of research would explore how the "free-will actions" ($F_{life}$, $F_{shell}$) influence the dynamics of these local blanket compressions, potentially leading to a new understanding of the quantum measurement problem and the role of consciousness as an active driver in the universe's informational evolution.

**References:**


[1] Philip Carmichael (2025) The Matryoshka Universe: An Investigation Into 4-Sphere Cosmology https://ai.vixra.org/pdf/2504.0044v1.pdf
[2] Philip Carmichael (2025) The Cypher Universe — Decoding Quantum Mechanics in the 4-Sphere https://ai.vixra.org/pdf/2504.0043v1.pdf
[3] Beate Krickel, Mariel Goddu: Cognitive Ontology in Terms of Cognitive Homology: The Role of Brain, Behavior, and Environment for Individuating Cognitive Categories https://philarchive.org/archive/KRICOI-2
[4] Emily Adlam, Carlo Rovelli (2022) Information is Physical: Cross-Perspective Links in Relational Quantum Mechanics https://arxiv.org/pdf/2203.13342
[5] Julian Barbour, Tim Koslowski and Flavio Mercati (2014): A Gravitational Origin of the Arrows of Time https://arxiv.org/pdf/1310.5167
[6] Julian Barbour, Niall ´O Murchadha (2018): Conformal Superspace: the configuration space of general relativity https://arxiv.org/pdf/1009.3559
[7] Julian Barbour, Zaza Doborjginidze, Tim Koslowski, Hemant Shukla (2024) Complexity and Its Creation https://arxiv.org/pdf/2405.07480
[8] Julian Barbour (2023) Gravity's Creative Core https://arxiv.org/pdf/2301.07657
[9] Kerr, R. (2023). Do Black Holes have Singularities? arXiv:2312.00841.
[10] Zhang, T. (2023). Quantum Unruh Effect on Singularities of Black Holes. Journal of Modern Physics, 14, 1526-1536.
[11] Qiuyu Ren, Michael Willis (2024) Khovanov homology and exotic 4-manifolds
[12] Chavanis, Pierre-Henri (2015) Cosmology with a stiff matter era
[13] Angela Chen (2023) Generalized Unruh effect: A potential resolution to the black hole information paradox
[14] V. A. Bailey (1959) The Steady-State Universe and the Deduction of Continual Creation of Matter
[15] Romeu Rossi Junior & Patrícia Kauark-Leite (2024) A Kantian Solution for the Freedom of Choice Loophole in Bell Experiments